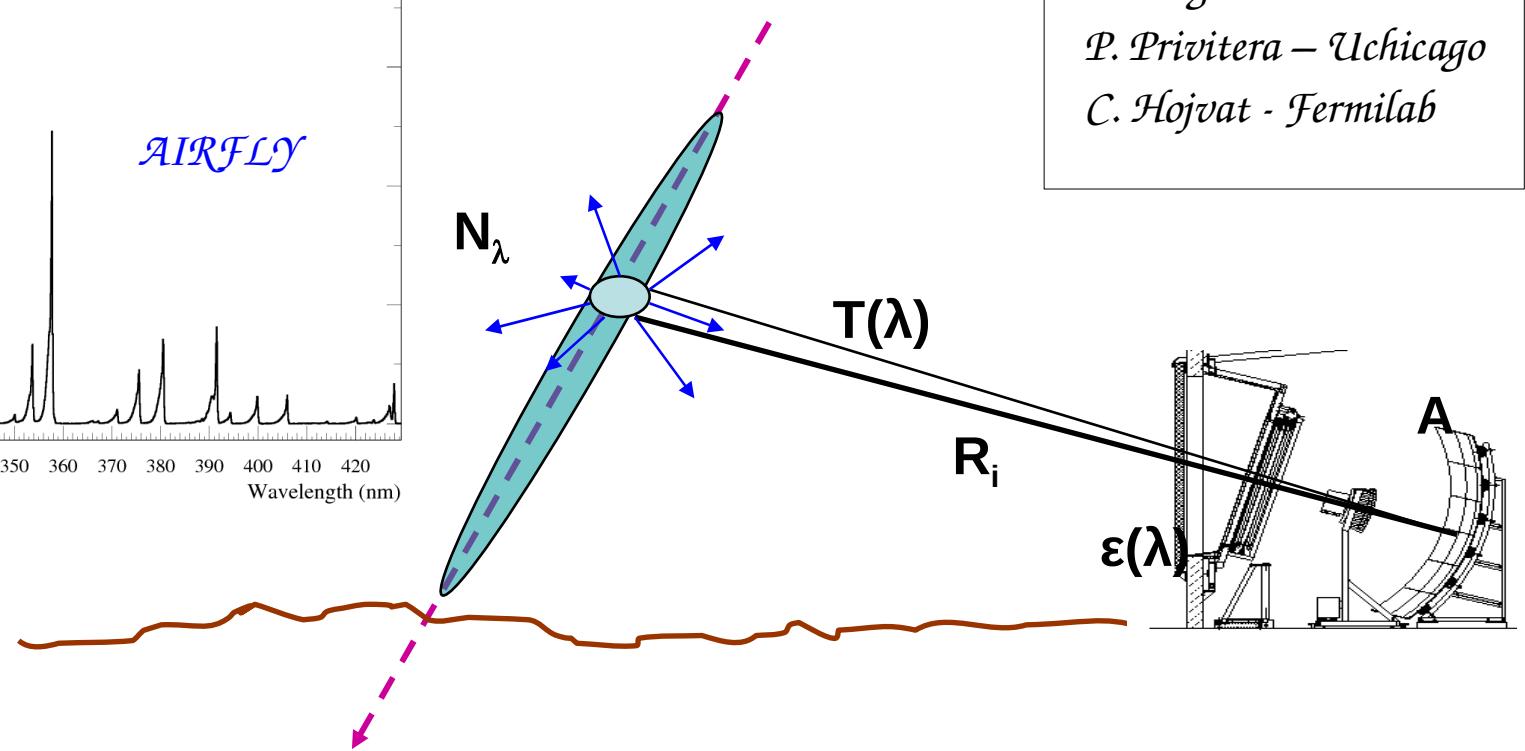
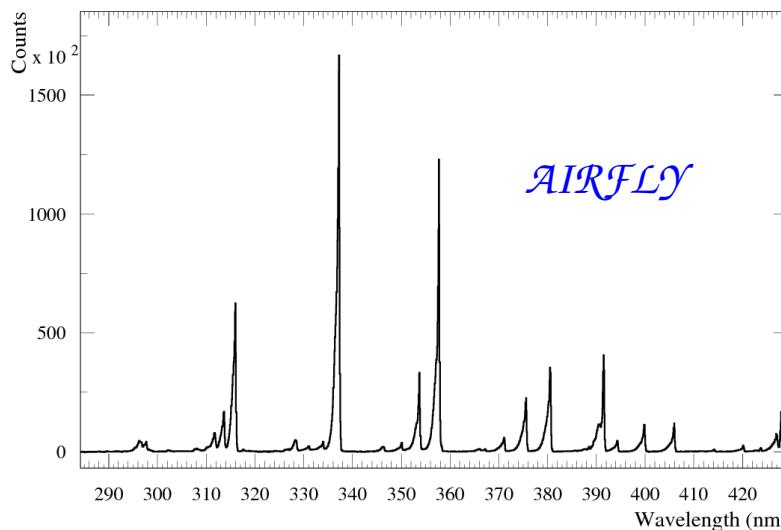




# Air Fluorescence Yield for UHE Cosmic Rays

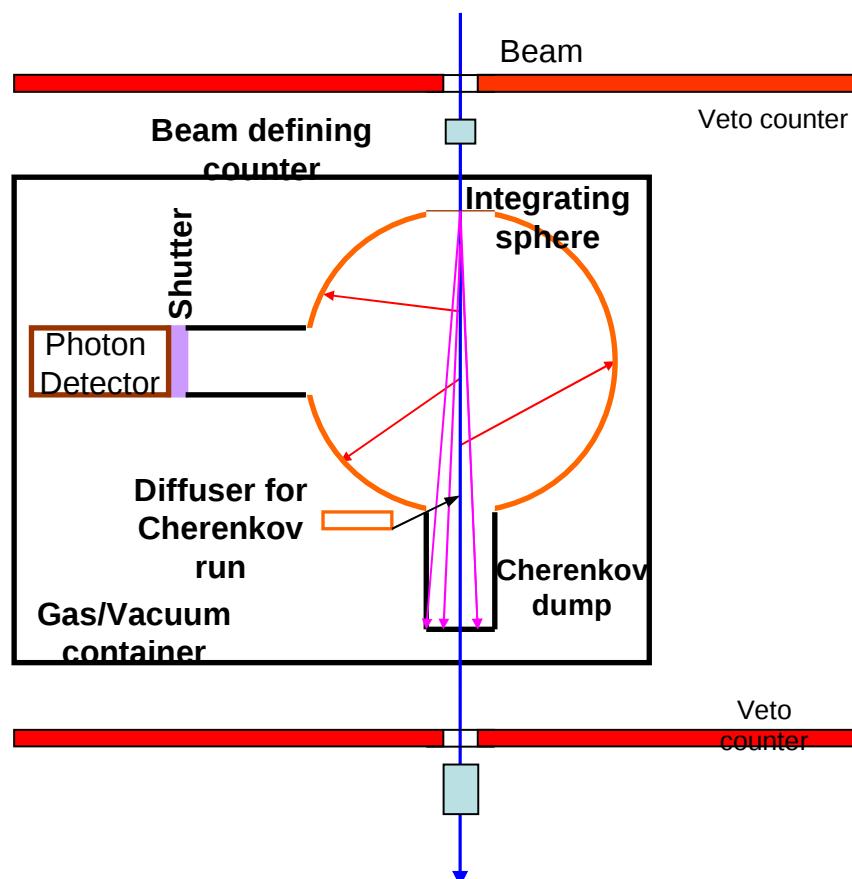
Martina Bohacova  
for the AIRFLY collaboration



*Uncertainties in the knowledge of the air fluorescence directly translate into the energy reconstruction of fluorescence detectors of cosmic rays*

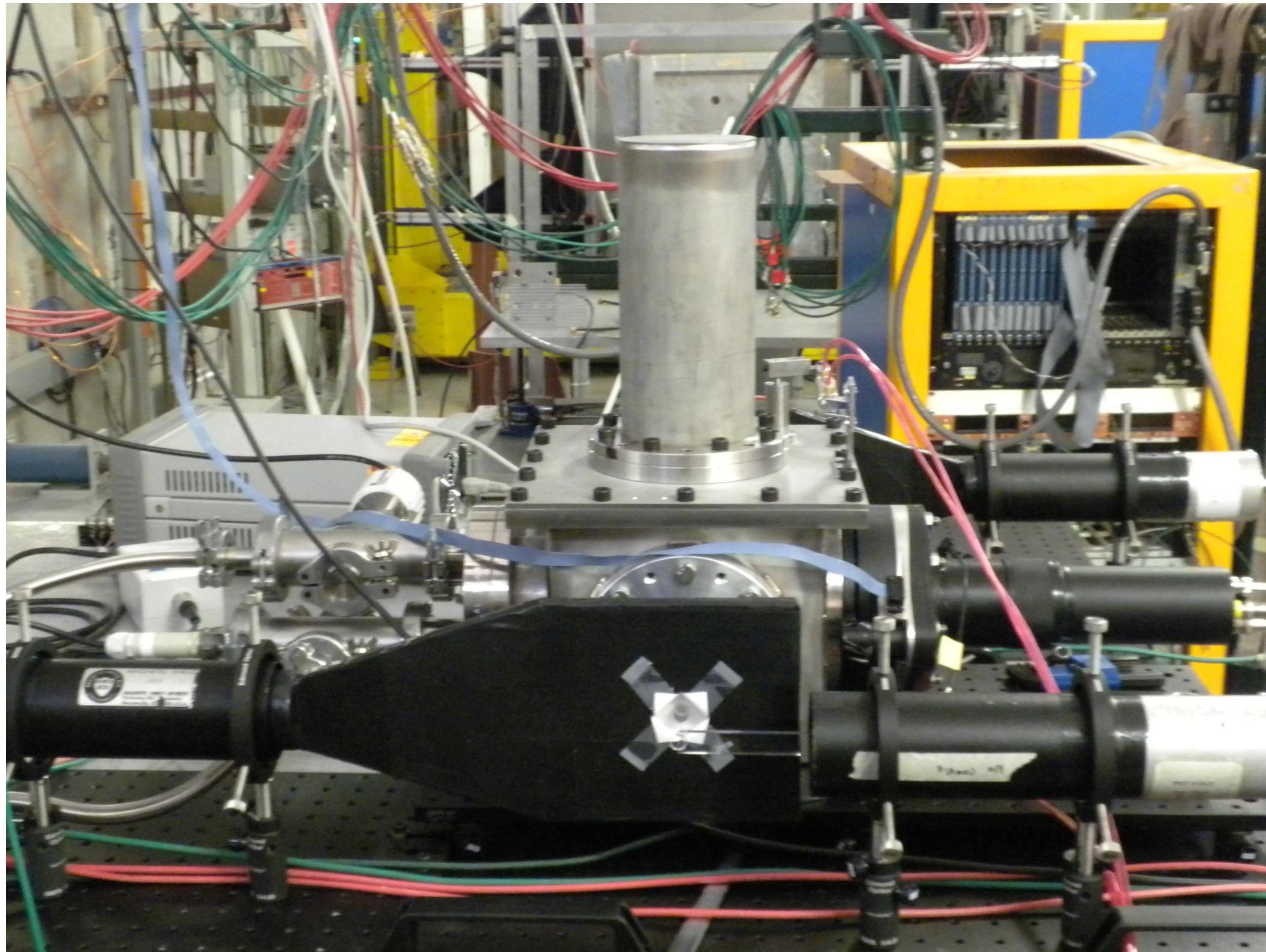
*Uchicago-Fermi  
strategic initiative  
P. Privitera – Uchicago  
C. Hojvat - Fermilab*

# Relative measurements: nitrogen spectrum, dependence on pressure, temperature, humidity, energy already completed – Frascati, Argonne



Absolute yield of the most prominent line (337 nm) – Fermilab

- high energy (120 GeV)
  - reduced multiple scattering
  - air as Cerenkov radiator
- well defined beam
  - single particle

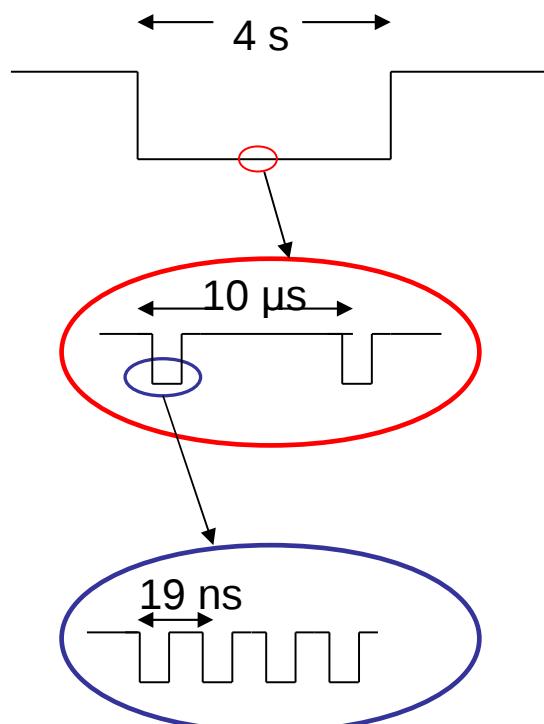




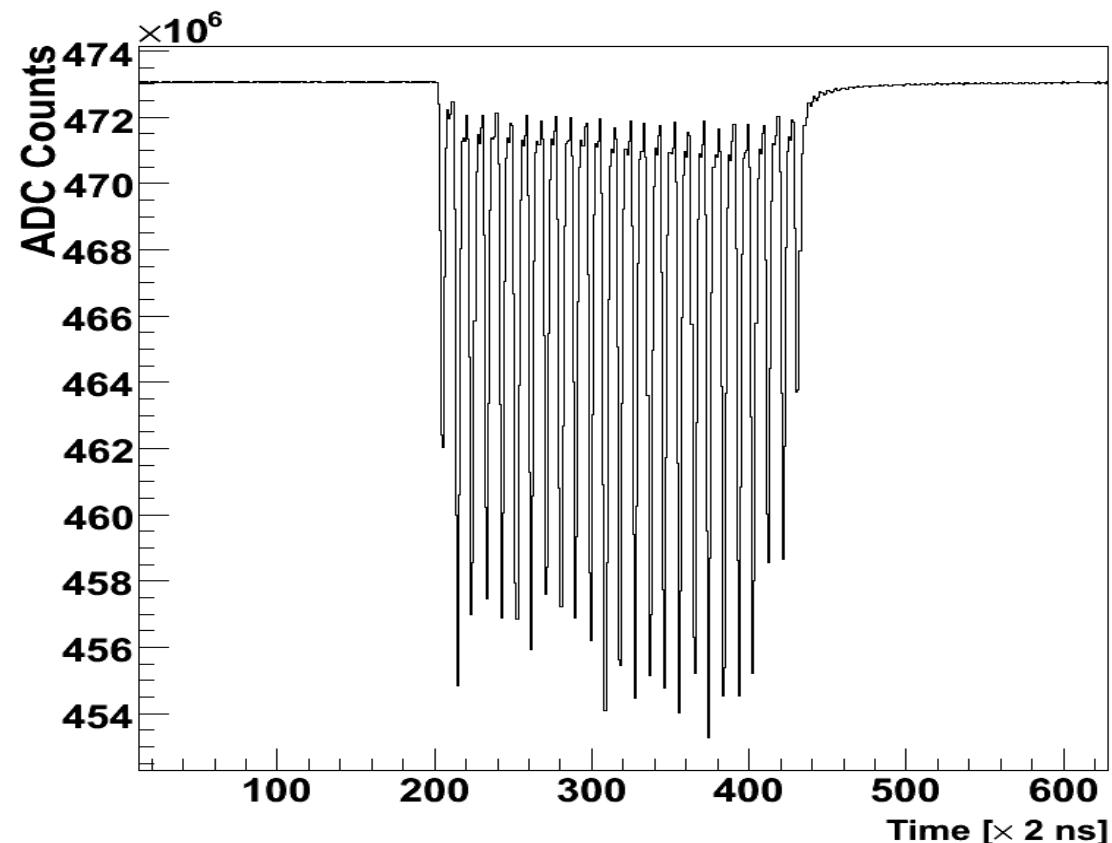
# Single particle triggering

1 spill / min

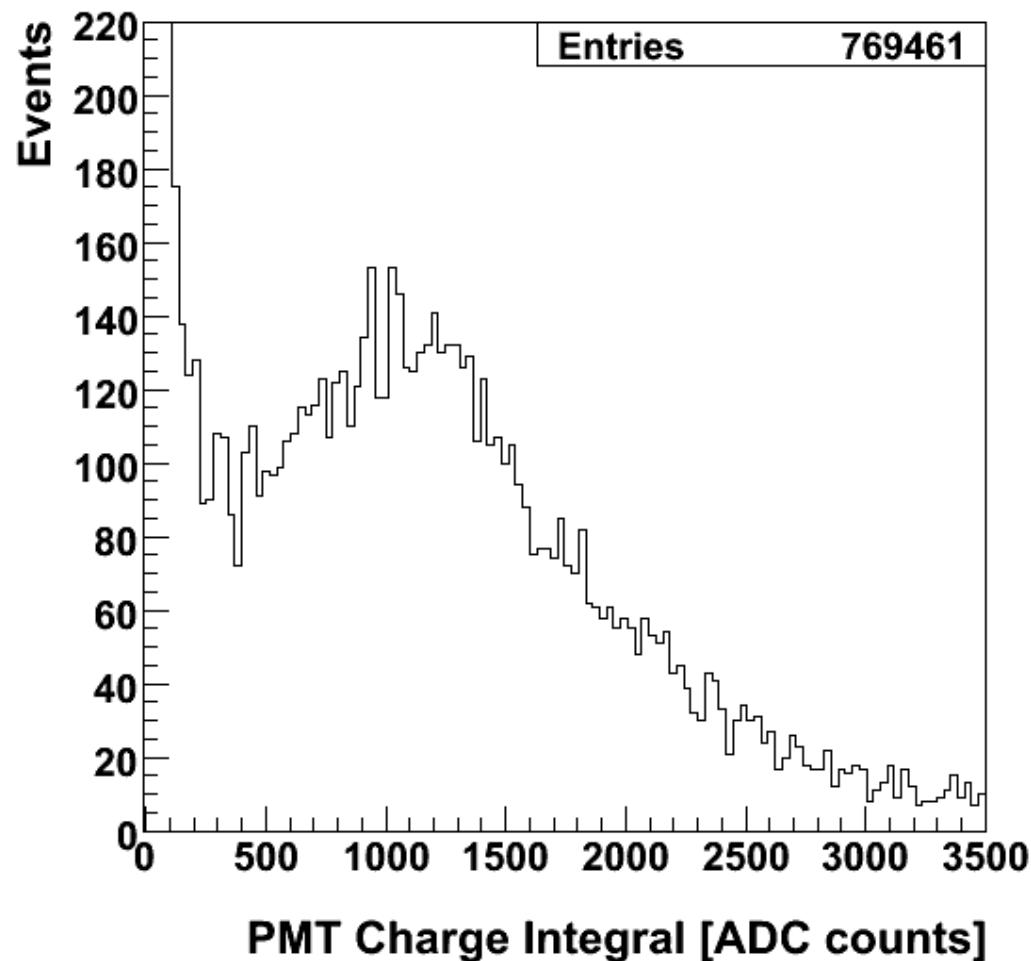
Several  $10^5$  particles/spill



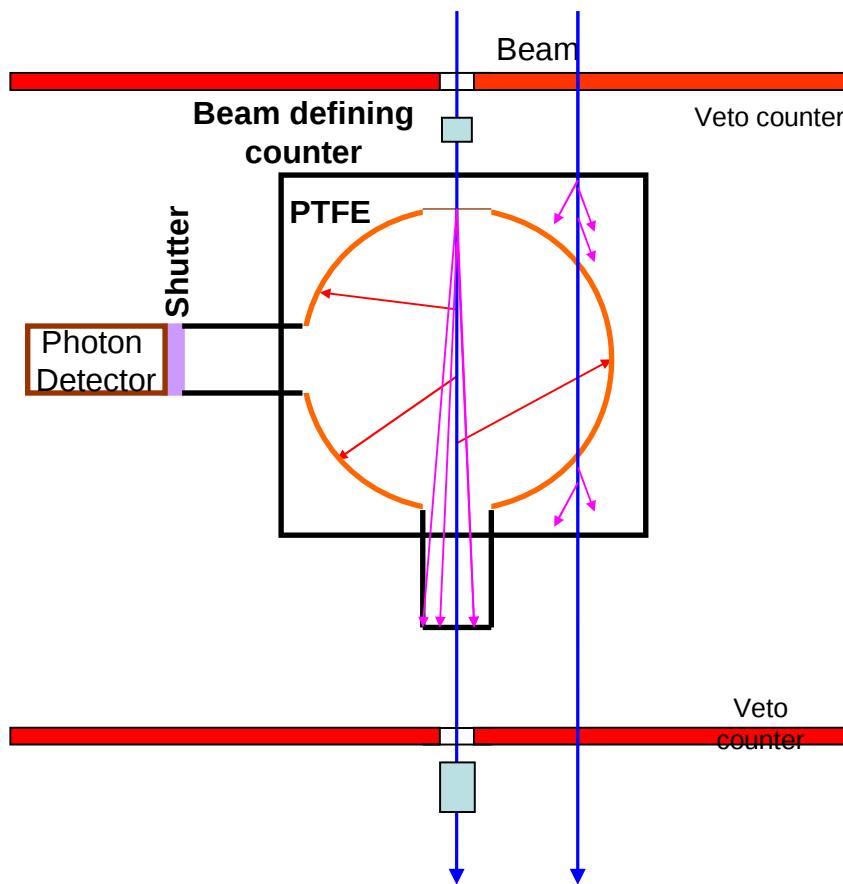
UV transparent acrylic rod



## *Single photoelectron spectrum*

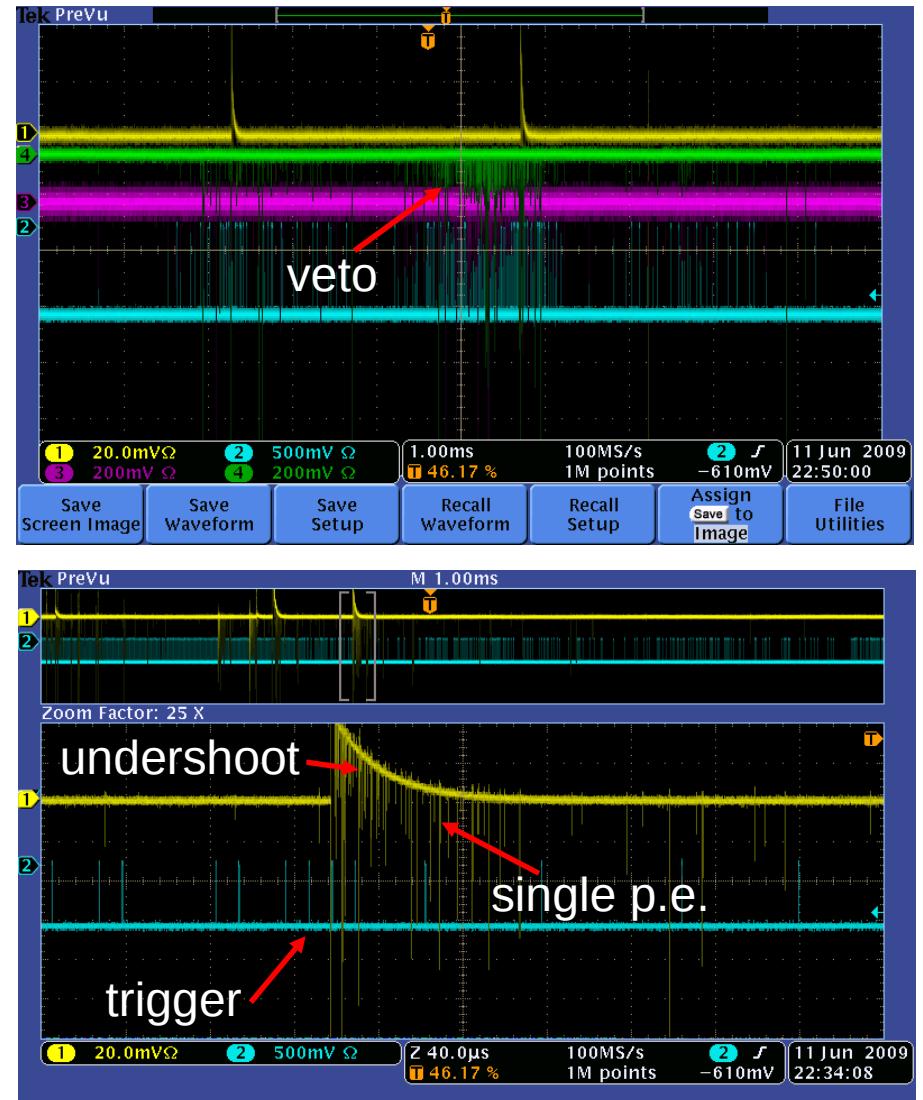


# *Sphere background*



*Photons created in the material of the sphere*

# *PMT afterpulse background*



$$B = 3.16 \pm 0.06 \cdot 10^{-4} \text{ ph/p}$$

- measured in a nonfluorescent gas

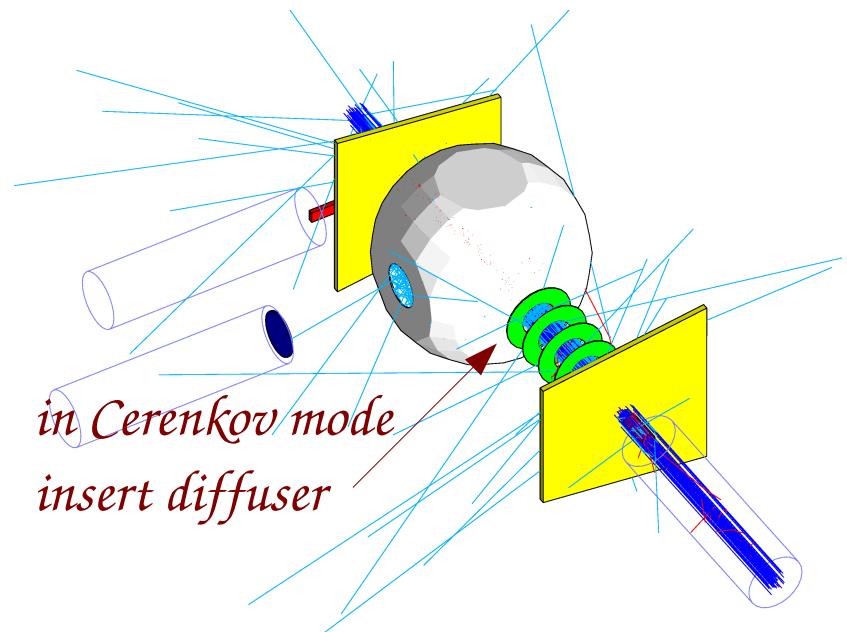


## Method and analysis

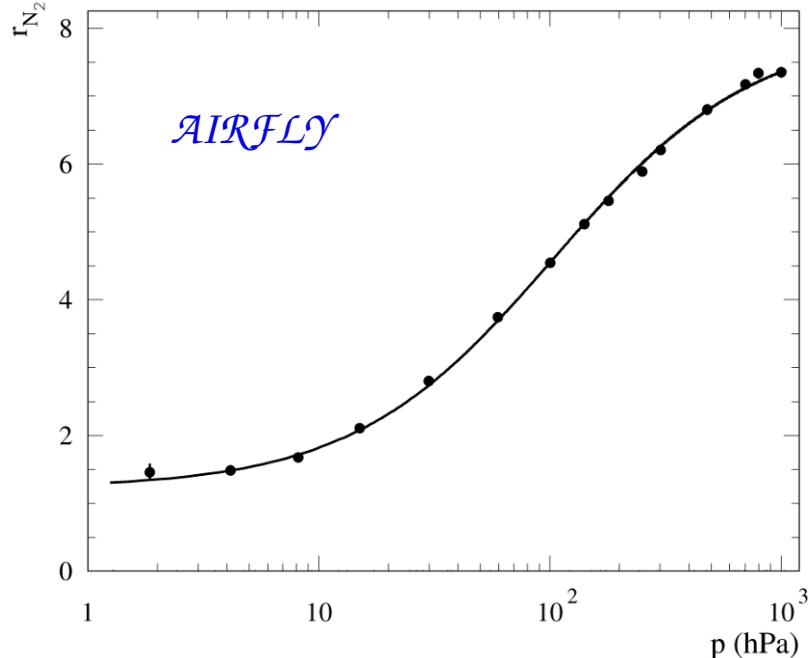
Compare fluorescence yield to a well known process to eliminate photo-detector systematics

$$\underbrace{N_{337}(\text{fluo})}_{\text{measured}} = \boxed{Y_{\text{fl}}} \times \underbrace{\text{Geom}_{\text{fluo}}}_{\text{MC}} \times \underbrace{T_{\text{filter}} \times QE_{337}}_{\sim \text{cancel}} \times \underbrace{N_p}_{\text{relative}}$$
$$\underbrace{N_{337}(\text{cere})}_{\text{measured}} = \overbrace{Y_{\text{cere}}} \times \overbrace{\text{Geom}_{\text{cere}}} \times \overbrace{T_{\text{filter}} \times QE_{337}} \times \overbrace{N_p}$$

- full Geant4 simulation of the experiment
- In the F/C many systematics cancel (integ. sphere)



## Preliminary results of June 2009 run



$$F/C(\text{meas.}) = 4.0 \pm 0.3$$

$$F/C(\text{simul.}) = 4.6 \quad \text{for} \quad Y = 5 \text{ ph/MeV}$$

*Due to background level*

- measurements were done in pure nitrogen
- $Y(N_2)/Y(\text{air}) = 7.35$ 
  - measured at Argonne with high accuracy

$$F = 11.3 \pm 0.1 \cdot 10^{-4} \text{ ph/p}$$

$$C = 2.9 \pm 0.2 \cdot 10^{-4} \text{ ph/p}$$

$$Y(337) = 4.3 \pm 0.3 \text{ (stat.) ph/MeV} \quad (7\% \text{ rel. uncertainty})$$

$$Y(337) = 5.05 \pm 0.71 \text{ ph/Mev} \quad \text{currently used by AUGER}$$



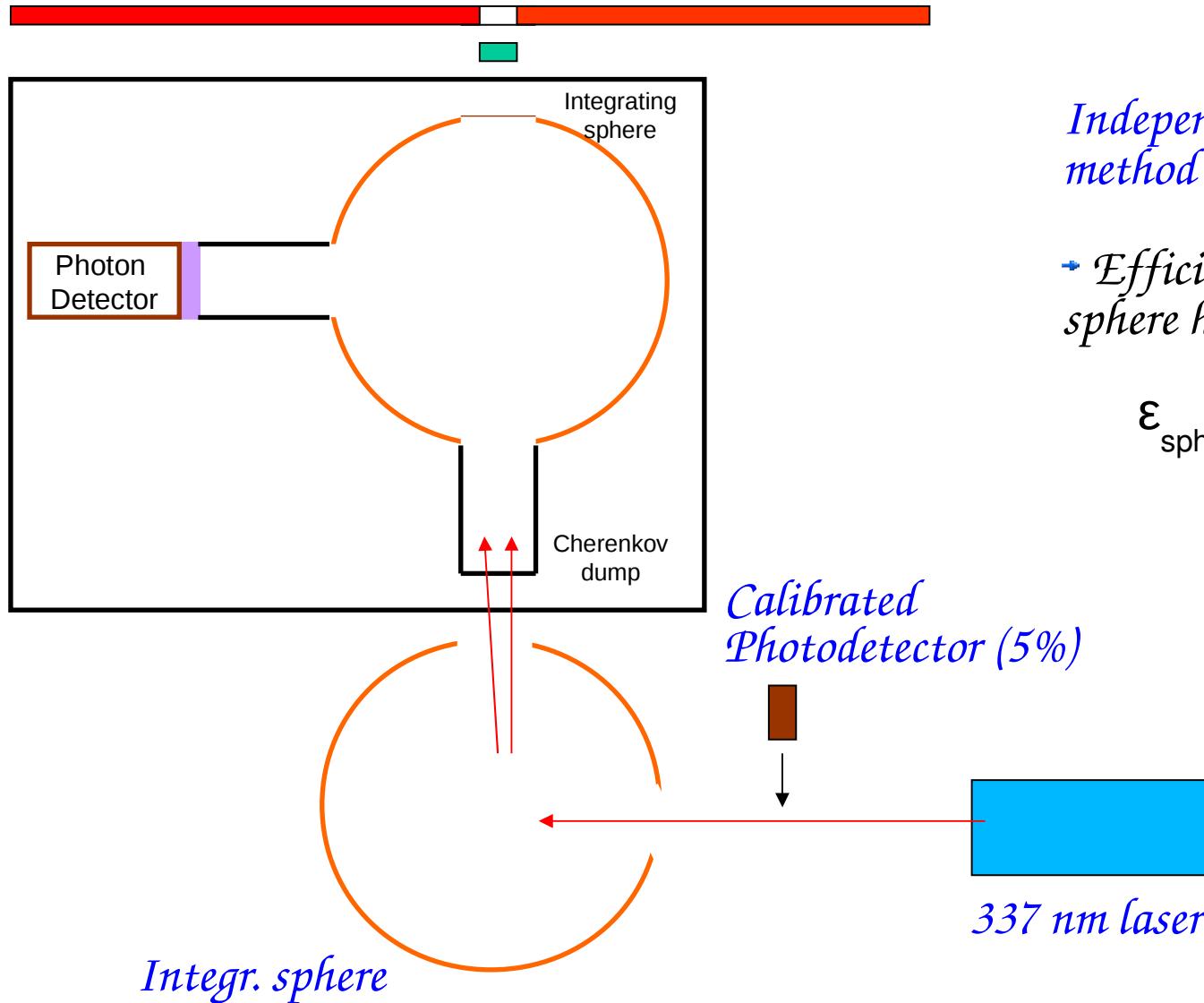
## *Systematic uncertainties*

- Reflectivity of the sphere ~ 1%
- PMT quantum efficiency ~ 1.5%
- Monte Carlo statistics ~ 1%
- N/Air ratio ~ 1%
- Geometry ~ 1%
- Filter transmittance ~ 1%

*Other sources of uncertainties are under investigation*

*Total systematic uncertainty is expected < 5%*

# *In situ laser calibration*

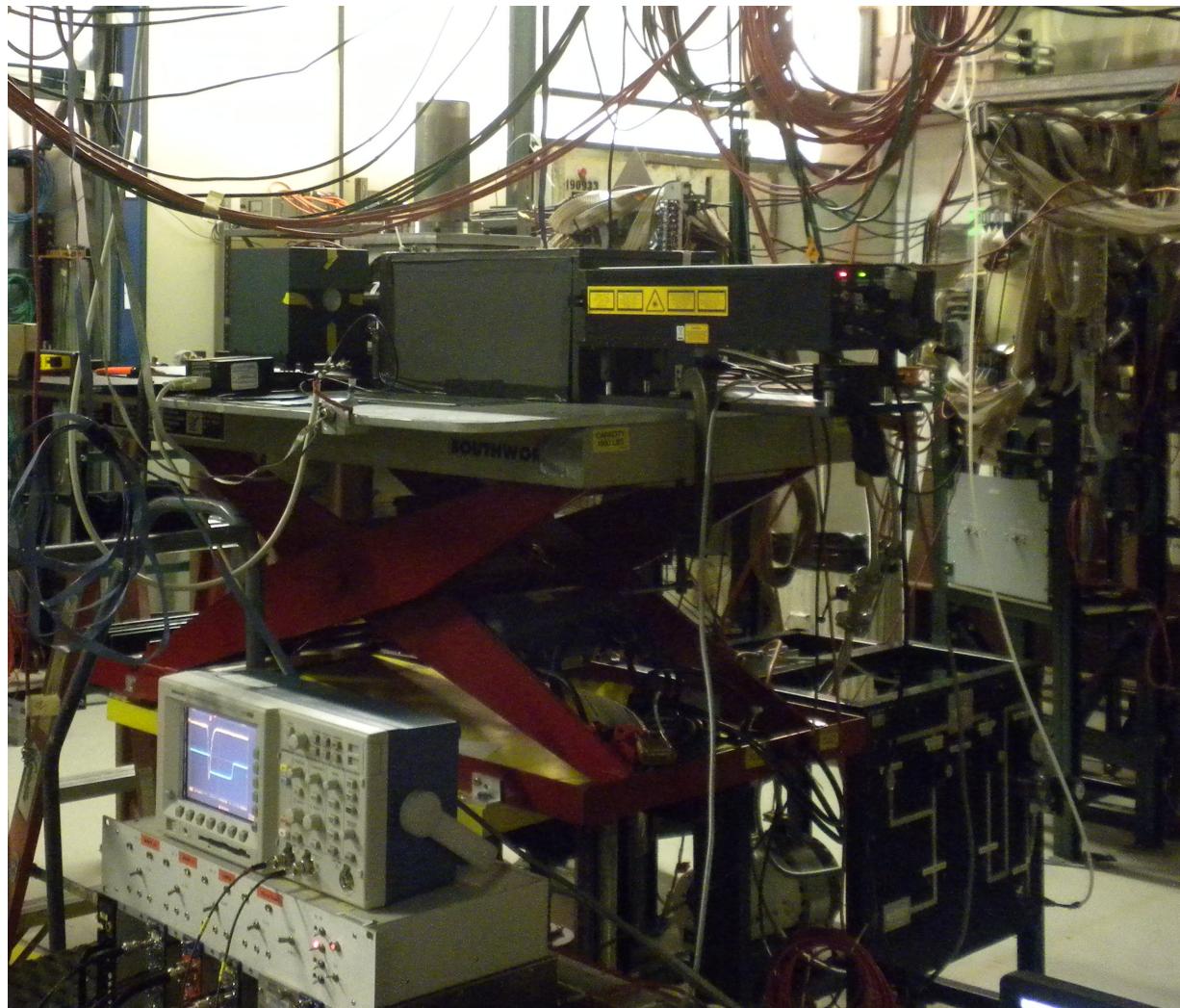


*Independent calibration method*

- Efficiency of the second sphere has to be measured

$$\varepsilon_{\text{sph}} = 1.82 \cdot 10^{-7}$$

*Total systematic uncertainty ~ 8%*



$$L = 7.3 \pm 0.2 \cdot 10^{-4} \text{ det/emit}$$

$$F/L(\text{meas.}) = 1.56 \pm 0.05$$

$$F/L(\text{simul.}) = 1.73 \quad \text{for} \quad Y = 5 \text{ ph/MeV}$$

$$\Rightarrow Y(337) = 4.5 \pm 0.1 (\text{stat.}) \text{ ph/MeV} \quad (3\% \text{ rel. uncert.})$$



# Outlook

- Air fluorescence yield was measured with  $< 10\%$  uncertainty
- Two independent methods give consistent results within 5%
- Test beam scheduled for December
  - thin integrating sphere (GORE material)
  - confirm June results with increased statistics
  - measurement of  $\gamma$  in air with UG6
  - laser calibration with syst. uncertainty  $\sim 5\%$
- December data are expected to give publishable results
- Additional measurement in spring 2010 (different particles,  $e^-$ ,  $\pi$ )